Organic Sponges for Cost Effective CVOC Abatement

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Abstract

Chlorinated solvents such as trichloroethene (TCE) are the most frequently found ground water contaminants. Many of the remediation technologies that are available for the treatment of soils and ground waters contaminated with these chlorinated volatile organic compounds (CVOCs), such as air stripping of ground water and soil vapor extraction of the vadose zone, result in a contaminated gas-phase stream. The Clean Air Act Amendments of 1990 strictly control release of such streams to the environment.

The processes that have been developed to treat CVOC-contaminated gas streams can be divided into two classes, those that capture and recover the CVOC and those that destroy the CVOC. Capture/ recovery processes are useful for cases where the CVOC has some value or its disposal cost as a neat solvent is low. Sorption onto activated carbon is the most common capture/ recovery process and is effective in many applications. However, there are many drawbacks associated with the use of activated carbon. Depending on the regeneration scheme used these may include:

- Low capacity at high relative humidity
- Relatively hydrophilic: readily adsorbs water
- Difficult to completely regenerate
- Need for periodic, high temperature (500-1000°C) reactivation
- Potential catalytic formation of HCl from CVOCs, especially with steam
- Potential fire hazard, due to the heat of adsorption
- Friable

Any of these properties can adversely affect process economics.

The goal of this work was to identify and evaluate synthetic sorbents that would not suffer from the same limitations as activated carbon when treating CVOC-contaminated air streams. Sorbents were classified into four groups: commercial polymeric sorbents (e.g. macroporous styrenic polymers); commercial carbonaceous sorbents (pyrolyzed polymers); commercial polymers and rubbers (e.g. polyether/ polyester block copolymers and ground rubber tires); and activated carbon.

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From an initial screening of more than 100 sorbents, ten were selected for further evaluation. The crucial performance properties of these potential sorbents were measured, including capacity for CVOC, effect of relative humidity, desorption rate, and dynamic behavior. Through this direct comparison of various sorbents and carbon under the same experimental conditions the strengths and optimal range of application of each of the sorbent classes were identified.

The commercial polymers and rubbers have a very high capacity for CVOCs from saturated vapors but their capacity at low concentrations is orders of magnitude below that of the other classes of sorbents. Thus, while not of value for treating air streams from remediation processes, the low cost of these materials may make them of interest in treating more concentrated industrial emissions.

For remediation applications - Dow's DOWEX™ OPTIPORE*, a polymeric sorbent, and Rohm and Haas' Ambersorb 563, a carbonaceous sorbent, are the best choices as replacements for activated carbon. DOWEX™ OPTIPORE* offers many advantages over activated carbon, including:

- similar, although slightly lower, capacity for CVOC
- CVOC capacity much less affected by relative humidity
- faster and more complete thermal desorption
- better dynamic performance in a column - quicker restoration of sorption capacity
- not friable - low attrition

Ambersorb 563, offers many of these same advantages, however, it is not as thermally regenerable and did not perform as well on repeated use in a column. It does, however, sorb much less water at higher relative humidities than does DOWEX™ OPTIPORE*. Overall, depending on the process requirements, either of these sorbents is a promising replacement for activated carbon for treating CVOC-contaminated air streams in remediation processes.

The principal drawback of these sorbents is their cost, which ranges from $55-$65/kg versus <$5/kg for activated carbon. Thus, the key to capitalizing on the many advantages commercial synthetic sorbents offer over activated carbon is to minimize the effect of their higher purchase price.

In this work, a sorption process using synthetic sorbents was developed based on standard packed bed technology. While this process offers a cost advantage over off-site regenerated activated carbon for high CVOC concentrations, designs using small sorber beds and hence short sorption cycle times are even more cost-effective. Various vendors have developed such processes, designed to take advantage of the favorable properties of synthetic sorbents while minimizing the impact of their higher cost. These implementations have been found to be cost-effective in field use, providing site remediators with an attractive alternative to traditional activated carbon systems for treating CVOC-contaminated air streams.

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